Relations between Autobiographical Memory and Hippocampal Subregion Volumes in Early Childhood

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Introduction

Autobiographical memory:
- Recollections of personal experiences and events.
- Requires mental time travel to recall details of previous events[1].

Early childhood development:
- Period of dramatic improvement in the ability to recall details from previous events[2], which may be due to brain development during this period[3,4].
- The hippocampus is a region in particular that may contribute to such changes[5].

Episodic I went to the beach.

Semantic I like the beach.

GOAL: To examine the relations between autobiographical memory and hippocampal volume in early childhood.

Methods

Participants: 200 participants, 4-8 years of age, (M=6.31, SD=1.49), 50% female

Neural Data Collection:
- A T1-weighted structural MRI scan (.9 mm^3) was obtained using a 32-channel coil on a Siemens 3T Trio scanner.
- T1 images were reconstructed and segmented using Freesurfer v5.1 (FSL)[6] and Automatic Segmentation Adapter Tool (ASAT)[7].
- The hippocampus was divided into head, body, and tail subregions using standard anatomical landmarks[5, 8] and adjusted for Intracranial Volume derived from Freesurfer[9].

Behavioral Data Collection:
- Autobiographical Memory Interview (AMI)- Parents provided details on two recent events in their child's life. Interviews involved three phases of questions.
  - Transcripts were scored using a modified Levine et al., 2002 protocol, aided by General Architecture for Text Engineering (GATE) software[10].
  - Event-internal details were summed across interview phases for both events to obtain a measure of episodic recall.
- Child Language Analysis (CLAN) was used to transcribe AMI audio records and calculate linguistic productivity Mean Length of Utterance (MLU)[11].
- Verbal IQ was estimated using age-appropriate subtests from the Wechsler Intelligence Tests for Children (WISC, WPPSI).

Free Recall Start
Event
Coarse-grained Location
Emotion
Repetition

*RSR: What can you tell me about your first rock concert? .
*CHI: I saw Heart .
*CHI: It was at Wolftrap .
*CHI: Really &-um really far away .
*CHI: But it was fun .
*CHI: A lot of fun .

Three Phases of AMI

Free Recall What do you remember about… going to the beach?

Prompted Recall Your mom said you played in the sand. What can you tell me about that?

Specific Probes Who was with you at the beach? Where was the beach?

Results

	Variable	Measure	Mean	SD	Range
Memory	Total Episodic Details	Summed event-internal details across both events	54.46	30.51	6-173
	Total Semantic Details	Summed event-external details across both events	19.38	12.60	0-66
Language	Morphemes/Utterance (MLU)	CLAN output of speech units per phrase length	6.21	1.92	2.33-11.74
	Verbal IQ	WISC, WPPSI score	13.33	2.88	4.00-19.00

Note. Outliers (±4 SDs) were excluded from analyses, resulting in one removal.

Behavioral Data Results:
- Children produced more episodic than semantic details: $t(189) = 17.91$, $p<.001$.
- Episodic memory correlated with MLU even after controlling for age: $r(191) = .69$, $p<.001$.

Bivariate correlations between children's memory, brain volumes, and covariates

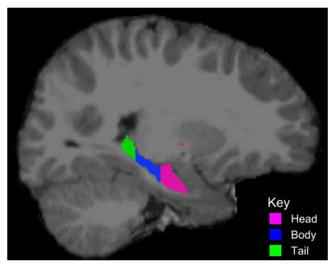
		1	2	3	4	5	6	7	8	9	10	11
1	Age											
2	Sex[1]	-.118										
Memory Scores												
3	Total Episodic Details	.446***	-.100									
4	Total Semantic Details	.114	.035	.469***								
Verbal Productivity Scores												
5	MLU	.569***	-.056	.746***	.395***							
6	Verbal IQ	.190**	-.071	.237**	.238**	.297***						
Hippocampal Volumes (Adjusted for ICV)												
7	Left Head Volume	.313***	.200**	.174*	.146	.201***	-.067					
8	Left Body Volume	.138	-.128	-.037	-.079	.005	-.028	-.358***				
9	Left Tail Volume	.142	.051	-.023	.071	.006	-.054	.255**	.023			
10	Right Head Volume	.280***	.229**	.154*	.119	.180*	-.028	.740***	-.277***	.203**		
11	Right Body Volume	.159*	-.031	-.023	-.033	.079	-.042	-.104	.571***	.099	.306***	
12	Right Tail Volume	.078	.063	-.034	.039	.038	.018	.076	.118	.674***	.109	.161*

Note. *$p < .05$, **$p < .01$, ***$p < .001$; Sex is coded 1, 2: 1 = Female, 2 = Male.

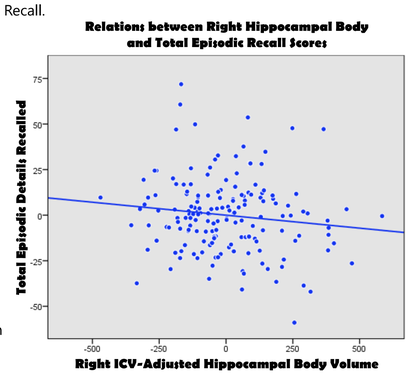
Neural Data Results:
- A multiple linear regression was used to examine relations between hippocampal head, body, and tail volumes in right and left hemispheres and total episodic recall controlling for age, sex, MLU, and Verbal IQ.
- **Results revealed this model accounted for 58.2% of variance in total episodic recall.**
- MLU and right hippocampal body volume were independent predictors, hippocampal volume receiving marginal significance.

Predictor Variables	*B*	*p*
Age	.05	.42
Sex	-.07	.20
Morphemes/Utterance	.73	<.001
Verbal IQ	.02	.68
Right ICV-adjusted hippocampal body volume	-.09	.10
Adj. R^2	.58	
F(5,163)	45.35	<.001

Regression coefficients predicting Total Episodic Recall.



Partial regression plot showing negative association between Right Hippocampal Body Volumes and Total Episodic Recall Scores, controlling for Age, Sex, MLU, and Verbal IQ.



Discussion

- When controlling for age, sex, Verbal IQ, and MLU, volume of the right hippocampal body was marginally related to total episodic recall scores, which reflect details children remembered about previous life experiences.
- The relation between autobiographical memory and hippocampal body volume was negative, meaning smaller body was related to higher scores, aligning with developmental data suggesting 'bigger' does not always mean 'better'[12].
- In addition, these findings are consistent with current theories about long-axis specialization of the hippocampus[2, 13].

TAKEAWAY: This study builds on previous findings which suggest improvements in autobiographical memory may be related to brain development, and supports the hypothesized relation between autobiographical memory and hippocampal development.

Future Directions

Longitudinal Investigation: Many children were involved in this study longitudinally (n≈75). Future work will investigate development of autobiographical memory over time, comparing performance in the same subjects across three years, and retention of memories for events from one or two years prior.

Neural Data: Future work will investigate autobiographical memory and other anatomical variables, such as cortical thickness. Future work will also test the hypothesized differential relations between the hippocampal head and tail with respect to fine-grained and course-grained time and location details[13].

Behavioral Paradigm: Future work will investigate the relations between the autobiographical memory task and other laboratory-based paradigms that are closed-ended or intentionally encoded, such as a temporal order task.

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